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A STUDY OF THE PROCESSING OF BARITE SAMPLES FROM SELECTED DEPOSITS IN NOVA SCOTIA

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A STUDY OF THE PROCESSING OF BARITE SAMPLES FROM SELECTED DEPOSITS
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R.K. Collings***, J-M. Lamothe**, S.S.B. Wang* and P.R.A. Andrews*

SUMMARY

Samples representative of four barite deposits in Nova Scotia were investigated in the laboratory by dry and wet gravity methods, including jigs, tables, spirals and, for one sample, magnetic separation, to determine the technical feasibility of producing a mud-grade product for off-shore oil and gas well drilling. Fines produced during processing were studied by froth flotation techniques. The chief criterion for barite for drilling mud applications is that it have a specific gravity of 4.2.

The specific gravity of two of the submitted samples, Scotsville and Brookfield, was greater than 4.2 as received. The Scotsville sample was high-grade; however, the high specific gravity of the Brookfield sample was, in part, due to the chief impurity siderite, its specific gravity being quite high at 3.9. That of the remaining two samples, Lake Ainslie and Pine Brook, was 3.77 and 4.04 respectively with the chief impurity being finely divided fluorite in the former, and calcite in the latter.

Beneficiation trials, both dry and wet, were essentially restricted to the Lake Ainslie, Pine Brook and Brookfield samples. Results indicated that the production of a mud-grade product from sized feed material was indeed possible but recovery of product, in most instances, was low.

Additional work was undertaken on two separate shipments of Scotsville barite at the request of the owners and consultants. This work is covered in Appendices 1 and 2.

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ÉTUDE SUR LE TRAITEMENT D'ÉCHANTILLONS DE BARYTINE
PROVENANT DE GISEMENTS SÉLECTIONNÉS EN NOUVELLE-ÉCOSSE

par

R.K. Collings***, J-M. Lamothe**, S.S.B. Wang* et P.R.A. Andrews*

RÉSUMÉ

Des échantillons représentatifs de quatre gisements de barytine de Nouvelle-Écosse ont été analysés en laboratoire selon les méthodes de gravité sèche et de gravité humide, ce qui inclue des gabarits, des tables, des spirales et, pour un échantillon, une séparation magnétique, dans le but de déterminer la faisabilité technique pour produire une boue de qualité pour le forage des pétroles off-shore et des puits de gaz. Les fines produites durant le traitement ont été étudiées à l'aide des techniques de flottation par moussage. La gravité spécifique de 4,2 de la barytine est le critère majeur pour des applications de boue de forage.

La gravité spécifique de deux des échantillons soumis, soit Scotsville et Brookfield, était plus haute que 4,2. L'échantillon Scotsville était de bonne qualité. La forte gravité spécifique de l'échantillon Brookfield était en partie due à une impureté majeure en sidérite, dont la gravité spécifique est assez forte à 3,9. Les deux autres échantillons, Lake Ainslie et Pine Brook, étaient respectivement à 3,77 et 4,04, avec une impureté majeure de fluorite finement divisée pour le premier et de calcite pour le deuxième.

Les essais d'enrichissement, tant secs que humides, ont été essentiellement restreints aux échantillons Lake Ainslie, Pine Brook et Brookfield. Les résultats ont montré que la production d'une boue de qualité faite à partir d'un matériel trié était en effet possible, mais la récupération du produit était dans la plupart des cas très faible.

Un travail supplémentaire a été effectué sur deux cargaisons séparés de barytine Scotsville à la requête des propriétaires et des consultants. Ce travail est couvert par les annexes 1 et 2.

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INTRODUCTION

As part of the Canada/Nova Scotia Mineral Development Agreement, samples of barite from four deposits, Scotsville, Lake Ainslie, Pine Brook and Brookfield, were delivered to the Non-Metallic Minerals Sub-Section for study and evaluation as sources of mud-grade barite, the prime criterion being that specific gravity should at least be 4.2 (89% equivalent BaSO_4).

The relatively high specific gravity of barite (4.5) suggests that separation of a mud-grade product from gangue material can be achieved by gravity methods, e.g., jigs, tables, spirals, heavy media. Such methods were evaluated during the preliminary portion of this study. Minus 150 μm fines from two samples, Scotsville and Pine Brook, being too finely divided for gravity methods, were evaluated by flotation to determine the feasibility of recovering mud-grade barite.

Subsequent to the above studies, two separate samples of Scotsville barite were received for further study and evaluation, specifically with regard to the feasibility of producing mud-grade barite from existing stockpiles to supply a company, in-hand order for then current off-shore drilling. The first, from Scotsville Mineral Resources, then owners/operators of the deposit, was a 200 kg sample of jig feed. The second, from Novacorp International, consultants to Scotsville, consisted of five individual, 50 kg samples from material stockpiled at Scotsville. Work conducted on the former is detailed in Appendix 1 and, on the latter, in Appendix 2 of this report.

The locations of the above-noted four sample areas are shown on the map, Fig. 1.

SAMPLE DESCRIPTION

Each of the four above-noted samples, weighing about 200 kg, was received in two separate boxes or bags. These were dumped into separate tubs and examined carefully. Both portions of each sample being similar, they were combined to provide four individual samples for study. These are described as follows:

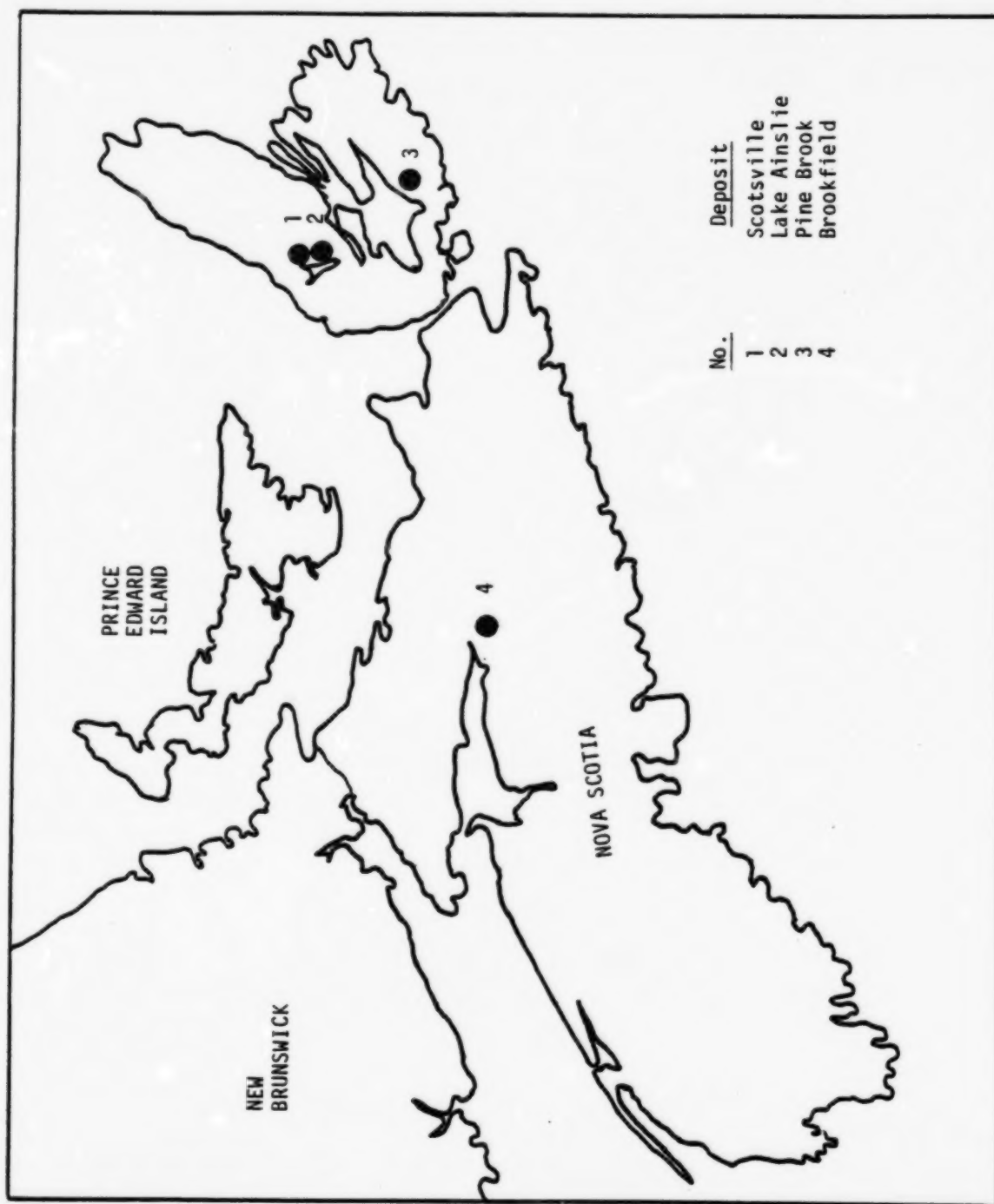


Fig. 1 - Locations of sampled barite deposits.

- Scotsville - Lumps up to 15 cm size of mottled grey to white barite; little evidence of carbonate.
- Lake Ainslie - Lumps up to 15 cm size of massive white to pink, green, and blue barite; several pieces showed 'vuggy' surfaces indicating surface/underground leaching action; also pieces of a blue/green mineral, possibly fluorite, an identified impurity in this deposit.
- Pine Brook - Lumps up to 15 cm size of white to grey barite with grey to green veinlets (stockwork) of an unidentified mineral; some pieces 'vuggy' and calcitic; primarily an impure mixture of barite, calcite, and the noted green to grey mineral.
- Brookfield - Lumps of white barite up to 15 cm size with irregular veinlets of brown siderite; minor surface coating of fine brown material on some pieces; little evidence of carbonate.

SAMPLE PREPARATION AND PROCESSING

All samples were separately reduced to minus 15 mm by stage crushing by jaw crusher, and hand screening. Sieve analyses, reported in Table 1, were made on representative samples. All fractions were examined by binocular microscope, principally to determine impurity content and liberation size, and the specific gravities determined by air pycnometer. These results also are reported in Table 1.

Selected portions from each of the four samples were treated by a variety of processes, e.g. dry jig and air table, wet jig and wet table, wet cyclone prior to tabling, and by pulverizing followed by wet table. Portions of fine, minus .15 mm material from the Scotsville and Pine Brook samples were studied by flotation.

The work carried out on these samples is separately described below under the individual sample headings.



Table 1. Description, MDA*-supplied samples

Sample**	Size (mm)	Wt %	Specific Gravity	Description
Scotsville	+5.0	49.7	4.26	Compound grains, grey/green and light brown impurity down to 0.3 mm; grains essentially free at 0.4 mm; 0.15 mm white to grey in colour, minor calcite and fluorite.
	-5.0, +2.4	23.9	4.30	
	-2.4, +1.2	7.4	4.30	
	-1.2, +0.6	7.2	4.32	
	-0.6, +0.3	4.7	4.31	
	-0.3, +0.2	1.6	4.28	
	-0.2, +0.15	1.3	4.28	
	-0.15	4.2	4.30	
TOTAL		100.0	(4.28)	
Lake Ainslie	+5.0	45.2	3.71	White to brown stained barite with green fluorite and minor calcite; finely divided; 0.15 mm white to grey in colour
	-5.0, +2.4	24.6	3.78	
	-2.4, +1.2	7.4	3.84	
	-1.2, +0.6	7.3	3.88	
	-0.6, +0.3	5.0	3.84	
	-0.3, +0.2	1.9	3.87	
	-0.2, +0.15	1.6	3.88	
	-0.15	7.0	3.87	
TOTAL		100.0	(3.77)	
Pine Brook	+5.0	52.8	4.02	Grey impure barite with significant percentage of calcite impurity, finely divided, liberation of impurity at 0.3 mm or finer; minor sphalerite and galena; 0.15 mm fraction grey in colour
	-5.0, +2.4	23.9	4.08	
	-2.4, +1.2	7.3	4.06	
	-1.2, +0.6	5.9	4.05	
	-0.6, +0.3	3.5	3.99	
	-0.3, +0.2	1.2	3.97	
	-0.2, +0.15	0.9	3.94	
	-0.15	4.5	4.02	
TOTAL		100.0	(4.04)	
Brookfield	+5.0	47.7	4.30	White barite with light to dark, reddish brown siderite impurity; impurity principally liberated at 0.3 mm; minor calcite; 0.15 mm pinkish brown in colour
	-5.0, +2.4	22.2	4.24	
	-2.4, +1.2	7.4	4.26	
	-1.2, +0.6	7.1	4.26	
	-0.6, +0.3	5.0	4.24	
	-0.3, +0.2	1.9	4.24	
	-0.2, +0.15	1.7	4.25	
	-0.15	7.0	4.28	
TOTAL		100.0	(4.27)	

*Canada/Nova Scotia Mineral Development Agreement

**As received but reduced to minus 15mm

SCOTSVILLE - MDA SAMPLE

An examination of an MDA-supplied sample of Scotsville barite, Table 1, showed this material to be high grade, i.e. 4.2⁺ S.G., in all the noted fractions. Although there was little to be gained by further processing, a representative fraction was checked in a small Denver jig. No significant beneficiation was achieved and no further work was undertaken on this sample.

As noted in the introduction, additional work was undertaken in two additional samples of Scotsville barite, a 200 kg sample of 'jig feed', and five, 50 kg samples of stockpile material. This work is detailed in Appendices I and II respectively.

LAKE AINSLIE - MDA SAMPLE

An examination of an MDA-supplied sample of Lake Ainslie barite, Table 1, showed this material to be relatively low grade, with no significant concentration of barite in any one size. Several approaches were investigated with a view to upgrading specific fractions to mud-grade specifications using both dry and wet beneficiation techniques.

Dry Beneficiation (Lake Ainslie)

Representative fractions of two of the coarser sizes of samples, minus 15, plus 5 and minus 5, plus 2.4 mm were initially investigated using a Knapp-Bates air jig. Results were disappointing there being little, if any, tendency toward concentration of the barite.

A representative sample of the coarser, plus 1.2 mm, head sample fraction was reduced by a combination of dual-roll crusher and small pulverizer to minus 1.2 mm, and a new size analysis determined (Table 2). Various fractions were then treated by air tables, the coarser minus 1.2, plus 0.6 and minus 0.6, plus 0.3 mm on the Kipp Kelly (600 x 1000 mm deck); the finer minus 0.3, plus 0.2, and minus 0.2, plus 0.15 mm on the Denver (300 x 500 mm deck). Middling products were crushed in a small hammer mill and recombined with the feed. The results, summarized in Table 2 and Fig. 2 indicate some potential for the recovery of mud-grade barite.

An attempt to produce a 4.2 S.G. concentrate by electrostatic separator using a minus 0.2, plus 0.15 mm head sample fraction was essentially unsuccessful (Table 2) although further work is indicated.



Table 2. Head, air table, and electrostatic results, Lake Ainslie barite

Size and S.G. of Head (reduced to -1.2 mm)	Air Table		Electrostatic	
mm	wt %	S.G.	-1.2 + 0.15 mm fractions (69.4% of Head)	-0.2 + 0.15 mm fraction (6.3% of Head)
-1.2, +0.6	33.4	3.75	wt %	wt %
-0.6, +0.3	22.3	3.76	net wt %	Net wt %
-0.3, +0.2	7.4	3.85		S.G.
-0.2, +0.15	6.3	3.81	conc	46.1
-0.15	30.6	3.87	tails	53.9
Total	100.0	(3.80)	fines*	3.4
				3.24
			Total	100.0
				6.3
				(3.61)

* 0.15 mm fines produced during size reduction of middlings from air table

** Net recovery of mud-grade (4.2⁺ S.G.) barite = 32.3 wt %

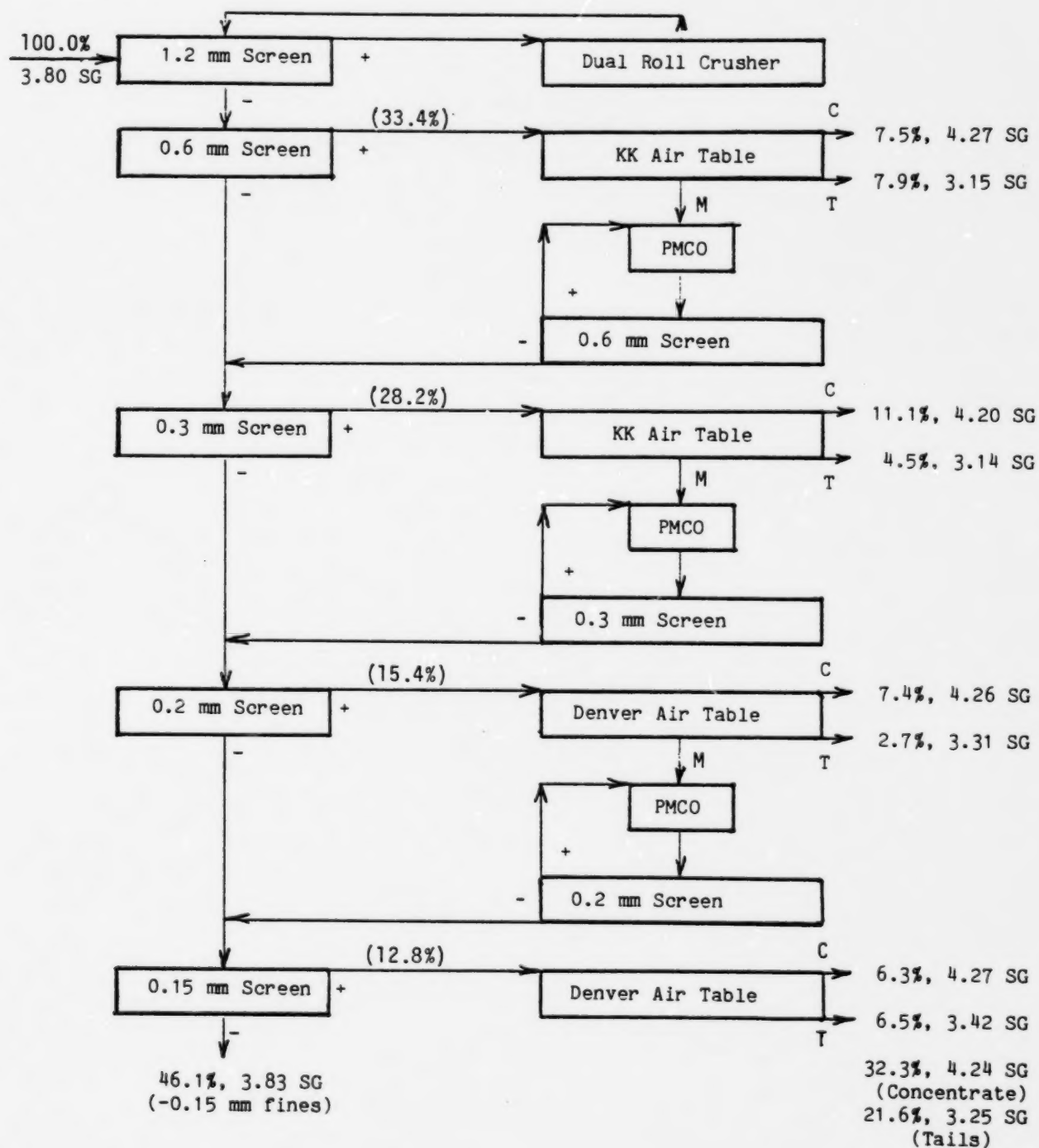


Fig. 2. Flow diagram for dry beneficiation, Lake Ainslie barite



Wet Beneficiation (Lake Ainslie)

A representative portion of the minus 5, plus 2.4 mm fraction of a head sample (wt % 24.6, S.G. 3.78, Table 1) was treated on a 10 x 15 cm Denver jig using 12.5 mm steel balls as ragging, the concentrate being repassed through the jig. The results, reported in Table 3, indicate some potential for the recovery of 4.2 S.G. barite for this mesh fraction and presumably for other fractions as well.

The minus 0.15 mm head sample fines (wt % 7.0, S.G. 3.87, Table 1) were treated in a hydrocyclone and the underflow and overflow products separately treated on a 45 x 100 mm Wilfley table. The results, summarized in Table 4, indicate some potential for the recovery of mud-grade barite.

Finally, a representative head sample was selected, reduced to 2.4 mm by a combination of jaw and roll crushing, screened at 1.2, 0.6, 0.3 and 0.15 mm, and the separate fractions treated in both jig and table as per the developed flow diagram, Fig. 3. The reject product from each jig stage was reduced by jaw and roll crusher, and combined with the feed material to the next stage. Results, reported in Table 5, indicate technical feasibility for the recovery of mud-grade material by this process.

Table 3. Wet jig results, -5, +24 mm fraction, Lake Ainslie barite

Feed Material	Jig Products			
		wt %	net wt %	S.G.
-5, +2.4 mm Head Sample fraction (24.6 wt %)	Conc.	60.7	14.9	4.00
	Rejects	39.3	9.7	3.36
	Total	100.0	24.6	(3.72)
Conc. from above test	Conc.	34.3	5.1*	4.23
	Rejects	65.7	9.8	3.95
	Total	100.0	14.9	(4.04)

*Net recovery of mud-grade (4.2⁺ S.G.) barite = 5.1%



Table 4. Wet table and cyclone results, -0.15 mm fraction, Lake Ainslie barite

Feed Material (43.0% of sample) Cyclone Products	Table Products			
		wt %	% total wt	S.G.
Underflow wt % 49.5 (21.3 net)	Conc.	35.8	7.6*	4.30
	Mids	31.2	6.7	4.04
	Tails	33.0	7.0	3.40
	Total	100.0	21.3	(3.88)
Overflow wt % 50.5 (21.7 net) 100.0 (43.0 net)	Conc.	27.8	6.0	4.12
	Mids	39.5	8.6	3.53
	Tails	32.7	7.1	3.60
	Total	100.0	21.7	(3.70)

*Net recovery of mud-grade (4.2+ S.G.) barite = 7.6%

Table 5. Wet jig and table test, head sample reduced to 2.4 mm, Lake Ainslie barite

Feed Material		Jig Concentrate		Table Products		Net Recovery	
Size, mm	wt %	wt %	S.G.	wt %	S.G.	wt %	S.G.
+1.2	18.8	3.4	4.25				
-1.2, +0.6	34.7	13.8	4.26			39.1*	4.25
-0.6, +0.3	30.0	12.1	4.24				
-0.3, +0.15	27.7			Conc.	9.8 4.23		
				Tail	17.9 3.49	17.9	3.49
-0.15	43.0					43.0	3.76
Net total	43.0**	29.3		27.7		100.0	

* Net recovery of mud-grade (4.2+ S.G.) barite = 39.1%

** For minus 0.15 mm fraction only.

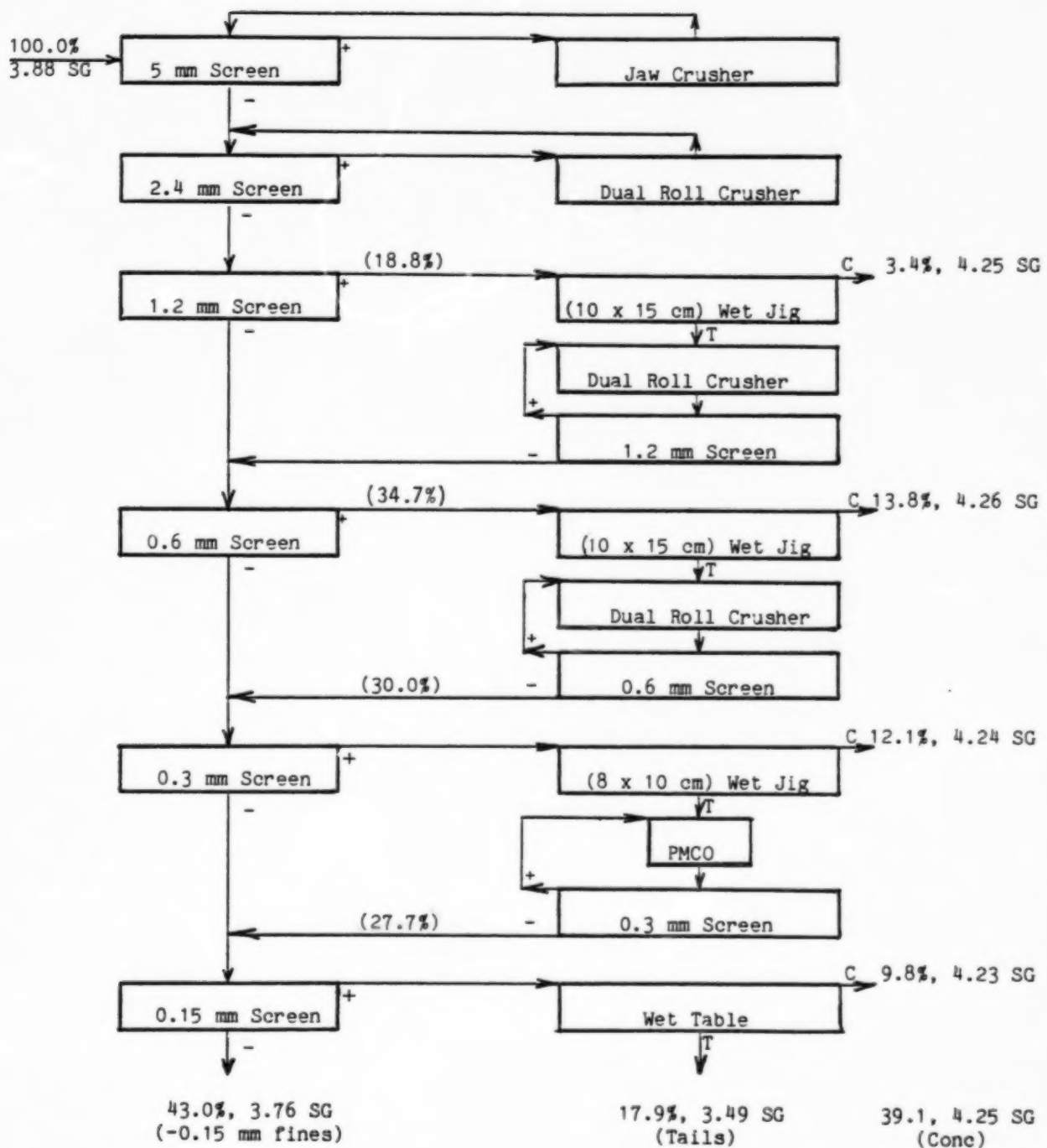


Fig. 3. Flow diagram for wet beneficiation, Lake Ainslie barite.



PINE BROOK - MDA SAMPLE

An examination of a MDA-supplied sample of Pine Brook barite, Table 1, showed this material to be relatively high grade with little concentration of barite in any particular size fraction. An initial, wet jig test on a representative sample of the minus 2.4, plus 1.2 mm portion of the head sample (S.G. 4.05) produced inconclusive results, the concentrate having a gravity of only 4.19, and the reject, a gravity of 4.03.

A sample of the plus 5 mm portion of the head sample (52.8 wt %, S.G. 4.02) was reduced by jaw and roll crusher to minus 1.2 mm and passed over a 45 x 100 mm deck Wilfley table. Results, reported in Table 6, show recovery of small percentages of mud-grade product as concentrate, with the overall recovery of such concentrate being slightly more than 21 per cent of the weight of feed and with a 4.27 S.G.

No further work was undertaken on this sample because of the finely divided nature of the interlocked calcite impurity.

BROOKFIELD - MDA SAMPLE

An examination of an MDA-supplied sample of Brookfield barite, Table 1, showed this material to be of apparent high grade, all fractions being 4.2⁺ S.G.; however, this high specific gravity was in part attributable to reddish-brown, siderite (iron carbonate) impurity. Pure barite has a S.G. of about 4.5, and siderite of 3.9.

Dry Beneficiation (Brookfield)

Gravity separation trials to separate the siderite using a 150 x 500 mm bed Knapp and Bates air jig for coarser sizes, and a 300 x 500 mm deck Denver air table for the finer fractions were unsuccessful.

Separation was then investigated using an Eriez magnetic roll separator, excellent results being achieved with all but the coarser, plus 5.0 mm size fraction. Results are reported in Table 7.

Wet Beneficiation (Brookfield)

Two wet beneficiation tests were made; the first with a representative portion of the minus 2.4, plus 1.2 mm head fraction using a 10 x 15 cm Denver jig, the second with a representative portion of the minus 1.2, plus 0.6 mm head sample using a 45 x 100 cm Wilfley table. The results, noted in Table 8, do not indicate a significant separation of the barite/siderite.



Table 6. Wet table tests, +5 mm fraction reduced, Pine Brook barite

Size Fraction			Wet Table											
mm	Wt %	S.G.	Conc.			Mids			Tails			Total		
			% wt	% total wt	S.G.	% wt	% total wt	S.G.	% wt	% total wt	S.G.	% wt	% total wt	S.G.
+2.4	23.9	4.08	-	-	-	-	-	-	-	-	-	-	-	-
-2.4, +1.2	7.3	4.06	31.7	2.3	4.22	52.2	3.8	4.10	16.1	1.2	3.94	100.0	7.3	(4.11)
-1.2, +0.6	26.6	4.05	28.8	7.7	4.25	57.6	15.3	4.12	13.6	3.6	3.85	100.0	26.6	(4.12)
-0.6, +0.3	16.6	4.04	41.7	6.9	4.29	43.0	7.1	4.13	15.3	2.6	4.07	100.0	16.6	(4.19)
-0.3, +0.2	5.3	4.03	34.8	1.8	4.29	49.1	2.6	4.14	16.1	0.9	3.56	100.0	5.3	(4.08)
-0.2, +0.15	3.8	4.02	25.4	1.0	4.32	60.7	2.3	4.13	13.9	0.5	3.56	100.0	3.8	(4.09)
-0.15	16.5	4.07	8.1	1.3	4.35	23.0	3.8	4.23	68.9	11.4	4.03	100.0	16.5	(4.10)
Total	100.0	(4.06)		21.0	(4.27)*		34.9	(4.13)		20.2	(3.96)		76.1	(4.12)

Net recovery of mud-grade (4.2 S.G.) barite = 21.0%

Table 7. Magnetic separation results, Brookfield barite

Size Fraction			Eriez Separator Products (2 passes)				
mm	wt %	S.G.*	Fraction	% wt	% total wt	S.G.*	%BaSO ₄
+5.0	47.7	4.30	**				
-5.0, +2.4	35.6	(4.29)	Mag.	13.7	4.9	3.89	20.72
			Midd.	3.9	1.4	4.13	50.28
			Light	14.1	5.0	4.26	67.04
			Heavy	68.3	24.3	4.40	93.32
			Total	100.0	35.6	(4.29)	-
-2.4, +1.2	18.7	(4.34)	Mag.	9.5	1.8	3.86	12.92
			Midd.	5.3	1.0	3.97	32.48
			Light	6.4	1.2	4.20	60.52
			Heavy	78.8	14.7	4.45	95.44
			Total	100.0	18.7	(4.34)	-
-1.2, +0.6	13.8	(4.35)	Mag.	16.1	2.2	3.90	19.60
			Midd.	1.6	0.2	4.23	68.88
			Light	2.4	0.3	4.25	74.30
			Heavy	79.9	11.1	4.46	98.40
			Total	100.0	13.8	(4.35)	-
-0.6, +0.3	9.6	(4.35)	Mag.	15.2	1.5	3.88	16.48
			Midd.	1.6	0.2	4.31	86.64
			Light	1.2	0.1	4.21	79.40
			Heavy	82.0	7.8	4.45	98.72
			Total	100.0	9.6	(4.35)	-
-0.3, +0.2	4.0	(4.35)	Mag.	13.2	0.5	3.86	10.84
			Midd.	1.7	0.1	4.21	82.40
			Light	1.3	0.1	3.98	76.76
			Heavy	83.8	3.3	4.45	98.72
			Total	100.0	4.0	(4.35)	-
-0.2, +0.15	3.5	(4.38)	Mag.	12.0	0.4	3.86	8.92
			Midd.	3.2	0.1	4.21	83.60
			Light	1.5	0.1	4.31	89.52
			Heavy	83.3	2.9	4.47	98.60
			Total	100.0	3.5	(4.38)	-
-0.15	14.8	(4.41)	Mag.	3.1	0.5	3.90	11.00
			Midd.	2.2	0.3	4.27	73.32
			Light	2.5	0.4	4.11	46.08
			Heavy	92.2	13.6	4.44	95.20
			Total	100.0	14.8	(4.41)	-

* Brackets indicate calculated values.

** Separation with +5.0 mm fraction was poor.



Table 8. Wet jig and table results, Brookfield barite

Size Fraction			Jig Products		
mm	wt %	S.G.		% wt	% total wt
-2.4, +1.2	7.4	4.26	Conc.	42.2	3.1
			Reject	57.8	4.3
			Total	100.0	7.4
					(4.29)
			Table Products		
-1.2, +0.6	7.1	4.26	Conc.	26.5	1.3
			Mids	59.8	3.0
			Tails	13.7	0.7
			Total	100.0	5.0
					(4.32)

FLOTATION STUDIES

The minus 0.15 mm fines from Lake Ainslie (45 per cent of crushed head sample, S.G. = 3.87) and Pine Brook (15 per cent of crushed head sample, S.G. = 4.17) samples were evaluated by flotation to determine the potential for recovering contained barite.

SAMPLE PREPARATION

Approximately 5 kg of each deposit were riffled into 1 kg lots for flotation evaluation. The specific gravity of a head sample for each deposit was measured and the theoretical analysis of barite calculated based on the assumption that the specific gravity of the gangue minerals was 2.9.

<u>Deposit</u>	<u>S.G.</u>	<u>% BaSO₄</u>
Lake Ainslie	3.87	~60
Pine Brook	4.17	~80

TESTWORK PROCEDURE

Flotation studies were conducted on each sample using Aerofloat 845, a synthetic modified sulphonate collector(1) to float barite, and sodium silicate to both disperse the pulp and depress quartz. Four tests were conducted on the Lake Ainslie sample, the results being reported in Table 9,

Table 9. Flotation tests conducted on the Lake Ainslie sample

Test No.	Product	Wt %	Analysis		Distribution %
			S.G.	% BaSO ₄	
1	Rougher float #1	47.6	3.96	66	53.7
	Rougher float #2	37.4	3.86	60	38.4
	Rougher tails	15.0	3.41	31	7.9
	Calculated head	100.0	3.85	(60)	10.0
2	Rougher float #1	20.5	4.03	74	25.4
	Rougher float #2	13.6	3.91	63	14.4
	Rougher float #3	49.3	3.87	60	49.6
	Rougher tails	16.6	3.50	38	10.6
	Calculated head	100.0	3.85	(60)	100.0
3	Rougher float #1	52.7	4.10	75	68.0
	Rougher float #2	11.4	3.77	54	10.6
	Rougher float #3	27.1	3.55	41	19.1
	Rougher tails	8.8	3.13	15	2.3
	Calculated head	100.0	3.85	(58)	100.0
4	Final concentrate	31.9	4.34	90	49.2
	Cleaner tails #3	9.7	4.08	74	12.3
	Cleaner concn. #2	41.6	4.28	86	61.5
	Cleaner tails #2	8.8	3.82	58	8.8
	Cleaner concn. #1	50.4	4.20	81	70.3
	Cleaner tails #1	8.0	3.34	30	4.1
	Rougher concn.	58.4	4.09	74	74.4
	Rougher tails	41.6	3.47	36	25.6
	Calculated head	100.0	3.83	(58)	100.0



and five on the Pine Brook sample, with results being reported in Table 10. Reagent concentrations are reported in Table 11.

The basic procedure was to stage-add collector, condition for 30 sec. and float for 1 min. The procedure selectively floats barite with respect to the gangue minerals. In tests with sodium silicate, the depressant was added prior to the collector.

TESTWORK RESULTS

Considering the Lake Ainslie sample, the purpose of Tests 1 and 2 was to establish the number of rougher floats and the collector concentration for each. Test 1 was abandoned after the second rougher float because an excessive amount of concentrate was floating when using 1.03 g/t collector for each rougher float. The results of Test 2 indicated that three rougher floats with 52 g/t of collector was sufficient to give a rougher recovery of 89.4%. In Tests 3 and 4, Na_2SiO_3 was added and a marked improvement was noted in the rougher recovery, which, in Test 3 increased to 97.7% for the same number of rougher floats and collector concentration as were used in Test 2. Test 4 was designed to ascertain the maximum grade of barite possible by multiple stage cleaning. In this test only two rougher floats were conducted so that the grade of rougher concentrate would be higher, as opposed to the lower grade obtained with three rougher floats. A higher grade rougher concentrate will generally allow a higher grade cleaner concentrate to be obtained. After the first cleaner, a mud-grade concentrate, of S.G. 4.2, was achieved at a recovery of 70.3%; after three cleaners a grade of 90.0%* barite was obtained for a recovery of 49.2%.

The testwork conducted on the Pine Brook sample was similar to the Lake Ainslie sample. Test 1 established that four rougher floats, with 51 g/t collector being added to each, was sufficient to give a recovery of 70.9%; the rougher tail, however, contained 65% barite. In Test 2 the number of rougher floats was increased to six with 52 g/t collector being added to each. The rougher recovery was increased to 98.1% but the rougher tail was only 5.3% weight. In each test, mud-grade barite at ~55% recovery was obtained.

* Reported analyses for barite are theoretically calculated based on a S.G. of 2.9 for the gangue minerals.



Table 10. Flotation tests conducted on the Pine Brook sample

Test No.	Product	Wt %	Analysis		Distribution %
			S.G.	% BaSO ₄	
1	Rougher float #1	26.5	4.27	86	29.5
	Rougher float #2	15.4	4.25	84	16.7
	Rougher float #3	10.5	4.21	82	11.1
	Rougher float #4	13.1	4.17	80	13.6
	Rougher tails	34.5	3.93	65	29.1
	Calculated head	100.0	4.14	77	100.0
2	Rougher float #1	19.6	4.28	86	21.5
	Rougher float #2	10.5	4.28	86	11.5
	Rougher float #3	9.2	4.29	87	10.2
	Rougher float #4	7.9	4.25	84	8.5
	Rougher float #5	30.5	4.18	80	31.2
	Rougher float #6	17.0	4.03	70	15.2
	Rougher tails	5.3	3.34	28	1.9
	Calculated head	100.0	4.15	78	100.0
3	Rougher float #1	44.0	4.33	89	49.6
	Rougher float #2	21.3	4.28	86	23.2
	Rougher float #3	11.1	4.22	83	11.7
	Rougher tails	23.6	3.73	52	15.5
	Calculated head	100.0	4.16	79	100.0
4	Rougher float #1	34.9	4.36	91	39.3
	Rougher float #2	30.2	4.28	86	32.2
	Rougher float #3	14.8	4.21	81	14.9
	Rougher float #4	6.1	4.24	84	6.3
	Rougher tails	14.0	3.57	42	7.3
	Calculated head	100.0	4.19	81	100.0
5	Final concentrate	20.7	4.48	99	25.1
	Cleaner tails #3	4.4	4.45	97	5.2
	Cleaner concn. #2	25.1	4.48	99	30.3
	Cleaner tails #2	10.3	4.33	89	11.2
	Cleaner concn. #1	35.4	4.40	96	41.5
	Cleaner tails #1	34.2	4.25	85	35.7
	Rougher concn.	69.6	4.35	91	77.2
	Rougher tails	30.4	3.87	61	22.8
	Calculated head	100.0	4.21	82	100.0

Table 11. Flotation reagent concentrations

Deposit	Test No.	Rougher Flotation				Cleaner Flotation				
		Time (min)	pH	Aero 845 g/t	Na ₂ SiO ₃ g/t	No. of Stages	Time per Stage	Range of pH	Aero 845 g/t	Na ₂ SiO ₃ g/t
Lake Ainslie	1	2	8.8	206	-	-	-	-	-	-
	2	3	8.8	156	-	-	-	-	-	-
	3	3	10.7	156	2577	-	-	-	-	-
	4	3	11.3	106	2637	3	3.8	10.7-9.2	58	-
Pine Brook	1	4	8.7	202	-	-	-	-	-	-
	2	6	8.6	312	-	-	-	-	-	-
	3	3	10.5	162	2178	4	-	-	-	-
	4	4	10.3	208	2089	-	-	4	-	-
	5	4	10.2	203	2029	3	3.0	9.8	152	1521



Test 3 and 4 were concerned with the depressant effect of Na_2SiO_3 on quartz. The best results were obtained in Test 4 where the recovery of mud-grade barite in four rougher floats, using 52 g/t collector for each float, was increased to 92.7%.

In Test 5, multiple cleaning was investigated in an attempt to produce the maximum grade possible barite. A barite concentrate analysing 99% barite was obtained after three stages of cleaning but recovery, at 25.1%, was low.

DISCUSSION AND COMMENT

Of the four samples studied, that from Scotsville, with a specific gravity of 4.28 as received, was the purest. Although a representative fraction was evaluated by wet jig, no significant increase in purity was observed.

The chief impurity in the Lake Ainslie sample was finely divided fluorite; however, there was no evidence of concentration of either the barite or fluorite in any particular size fraction. Dry beneficiation trials by air table were disappointing although some improvement in grade and recovery was effected by crushing, sizing and recycling the middling products. Net recovery of mud-grade, 4.2 S.G. barite, was 32.3 per cent. Wet separation trials by jig and table gave a concentrate of 4.25 S.G. with a recovery of 39.1 per cent of the feed.

The chief impurity in Pine Brook barite was finely divided calcite. This sample, at 4.04 S.G., was slightly purer than Lake Ainslie but, as with Lake Ainslie, there was no marked tendency for either the barite or calcite to concentrate in any one size. Wet processing by jig resulted in little improvement. Better results were achieved with the Wilfley table, with net recovery of 4.2 S.G. barite being 21.0 per cent.

Dry beneficiation trials by air jig and table with Brookfield barite were generally unsuccessful due to the relatively high specific gravity (S.G. 3.9) of the principal impurity, siderite. Wet trials by jig and table were similarly unsuccessful. Trials with the Eriez magnetic separator were more promising. Flotation trials on the 0.15 mm fines from Lake Ainslie (45 per cent of head) and Pine Brook (15 percent of head) demonstrated that it was possible to recovery mud-grade product from each. Recovery for Lake Ainslie

was 70.3 per cent or 31.6 per cent of head sample and, for Pine Brook, 92.7 per cent or 13.9 per cent of the head sample.

Recoveries could be improved by further testwork employing depressants for fluorite and calcite, which were not studied in this investigation. Similarly, the low recoveries experienced while producing high grade >90% barite concentrates could be improved by the use of fluorite and calcite depressants.

CONCLUSION

On the basis of the results of the work outlined in this report, the recovery of significant tonnages of mud-grade barite from each of the four noted deposits is possible. Grades and recovery of product will, of course, depend to a large degree on the effective 'freeing' of contained impurities prior to wet or dry processing by gravity method or, in the case of Brookfield, magnetic separation, and the treatment of reject fines by flotation.

REFERENCES

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ACKNOWLEDGEMENTS

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APPENDIX I

Scotsville Mineral Resources Sample

Following completion of the study described in this report, CANMET assisted in the further evaluation of a 200 kg sample of minus 15 mm 'jig feed' provided by Scotsville Mineral Resources, owners of the Scotsville deposit, specifically to determine the technical feasibility of recovering mud-grade barite from this feed sample.

A representative portion was wet screened on 2.4, 0.6, 0.3 and 0.15 mm sieves to clean the grains and remove the fines. Various fractions were then processed by wet jig and table and the specific gravities of all fractions determined by air pycnometer. The results are reported in Table 12.

Jig and wet table tests of various sized fractions, Table 12, resulted in concentrates meeting the 4.2 S.G., mud-grade specification. Total recovery of best product for all sized fractions was 53.6% which product contained 78.7 per cent of the total barite and had a specific gravity of 4.26. This was achieved by a combination of jigging for the two coarser sizes, plus 2.4, and minus 2.4 plus 0.6 mm; tabling for the finer sizes, minus 0.6, plus 0.3 and minus 0.3, plus 0.15 mm; and cyclone treatment of the minus 0.15 mm fines.

Thus, two approaches to the recovery of mud-grade barite from the supplied, 'jig feed' material could be considered:

1. removal of the plus 2.4 mm, and minus 2.4, plus 0.6 mm fractions followed by separate treatment of each in two parallel jig circuits. The minus 0.6 mm could then be treated by wet table, and the minus 0.15 mm by cyclone or spiral classifier to recover additional mud-grade material.
2. removal of the plus 0.6 mm fraction followed by jig treatment. The minus 0.6 mm could then be treated by wet table, and the minus 0.15 mm by cyclone or spiral classifier to recover additional mud-grade material.



CONCLUSION

The results of this study indicate that it is technically feasible to recovery at least 50% of the supplied 'jig feed' as mid-grade barite (S.G. 4.2) by a combination of sizing followed by wet jig and table concentration. Additional recovery of product could be realized by further treatment of the 0.15 mm fines by spiral or cyclone concentration.



Table 12 - Jig and table results - Sootsville barite

Size Fractions			Test No. and Unit	Conc.			Mids			Tails			Total		
mm	wt %	S.G.		wt %	dist %	S.G.	wt %	dist %	S.G.	wt %	dist %	S.G.	wt %	dist %	S.G.
+2.4,	39.0	3.71	6 - jig	24.6	36.1	4.27*				14.4	5.0	2.96	39		3.67
+0.6			5 - jig	33.9		4.25				37.8		2.98	71.7		3.47
-2.4, +0.6,	32.7	3.72	4 - jig	22.3	33.0	4.23*				10.4	1.7	2.81	32.7		3.64
-2.4, +0.6,	32.7	3.72	1 - table	15.7		4.17	13.8		3.54	3.2		2.82	32.7		3.72
-2.4, +0.6,	32.7	3.72	2 - table	5.1		4.21	22.7		3.82	4.9		2.80	32.7		3.67
-0.6, +0.3,			10 - table	2.0	3.0	4.31*	1.5	1.6	3.67	0.9	0.1	2.74	4.4	4.7	3.62
-0.3, +0.15			9 - table	1.6	2.2	4.27*	2.9	3.0	3.76	1.4	0.2	2.80	5.9	5.4	3.58
-0.6, +0.15	10.3	3.61	3 - table	3.3		4.25	6.1		3.59	0.9		2.73	10.3		3.67
-0.15 (cyclone overflow)	8.9	3.38	8 - table	3.1	4.4	4.35*	2.3	2.5	3.78	3.5	1.3	3.0	8.9	8.2	3.58
-0.15 (cyclone underflow)	9.1									9.1	5.9	3.24	9.1	5.9	3.24
Total **	100.0	(3.64)		53.6	78.7	(4.26)	6.7	7.1	(3.75)	39.7	14.2	(2.97)	100.0	100.0	(3.61)

* Best product (test), each size fraction

** Total, best test, each fraction



APPENDIX II

Novacorp International Samples

Following completion of the study described in this report, CANMET assisted in the further evaluation of Scotsville barite in response to a specific need by the owners, Scotsville Mineral Resources, and consultants, Novacorp International, to demonstrate the technical feasibility of producing a mud-grade product to supply existing orders for off-shore drilling activity.

Five samples of stockpile material were shipped to CANMET for evaluation, particularly with regard to optimum size for subsequent treatment, and specifically to provide information on optimum size of jig feed to enable the consulting firm, Novacorp, to arrange the wet-jig production of tonnage lots of product from stockpile material to fill on-hand orders for mud-grade barite.

These samples, each weighing about 50 kg, are described as follows:

- Sample No. 1 - High-grade, white to grey-white barite; minus 15, plus 5 cm. in size; little evidence of carbonate, two or three small pieces of dark impurity which represented up to 5% of total volume. Impurities identified by the Process Mineralogy Section included minor calcite, fluorite, quartz and microcline.
- Sample No. 2 - Medium grade, white to green-grey barite; minus 15, plus 5 cm. in size; little carbonate, eight to ten pieces of dark impurity which represented up to 15% of total volume. Impurities identified by the Process Mineralogy Section included minor quartz, orthoclase, albite, calcite and fluorite.
- Sample No. 3 - Medium to low grade, white to pink barite; minus 15, plus 5 cm. in size; 50% by volume of dark, impure wall rock, some intermixed in coarse sizes with barite. Impurities identified by the Process Mineralogy Section included minor calcite and calcium silicate.



Sample No. 4 - Low grade material; sample composed of 1/3 white to grey barite, 1/3 low grade barite, 1/3 dark, friable mineral impurity; material essentially minus 15, plus 5 cm in size but fines (minus 5 cm) represent about 15% by volume. Impurities identified by the Process Mineralogy Section included quartz, calcite and orthoclase.

Sample No. 5 - Low grade material; sample composed of 50% vuggy barite and 50% impure wall rock (soft); generally minus 15, plus 5 cm in size with minus 5 cm. representing about 15% of total volume. Impurities identified by the Process Mineralogy Section included quartz, biotite, calcite and minor pyrite.

SAMPLE PREPARATION AND PROCESSING

All five samples were initially screened to separate the impure, minus 2.5 cm fines. Following this, both the plus 2.5 cm and minus 2.5 cm fractions of the samples were reduced in size, the former to 2.5 cm by jaw crusher, the latter to 2.5 mm by jaw and roll crushers. Size analyses were made of representative samples from all crushed products and all fractions were examined by binocular microscope. The plus 2.5 cm, sized fractions were checked by heavy liquid separation using liquids of 2.97 and 2.30 S.G. Results are reported in Tables 13 to 16.

GENERAL COMMENTS

Specific gravity determinations for head samples of the five submitted samples indicated that samples 1 and 2, with S.G. respectively of 4.09 and 3.85, were of higher purity than 3, 4 and 5, with respective specific gravities of 3.47, 3.49 and 3.47.

Although the initial removal of minus 2.5 cm fines from samples 1 and 2, in particular, would not be necessary, these fractions representing only 1% of the total and of reasonable grade (3.40 to 4.18 S.G.), removal of the minus 2.5 cm from samples 3, 4 and 5, however, would be beneficial prior to further processing, this fraction being low in barite and relatively high in calcite impurity.



Heavy liquid separation test results indicate that specific gravities approaching or exceeding mud-grade specification (4.2 S.G.) can be produced with the plus 2.5 cm fractions of all five samples provided samples are crushed to pass a 2.5 cm screen. The S.G. of the sink products for samples 1 to 5 were, respectively, 4.25⁺, 4.19⁺, 4.19⁺, 4.18⁺, 4.23⁺ with respective recoveries of 89.5, 76.4, 51.3, 47.6, and 43.3 of feed material.

The increase in specific gravity with decrease in particle size, Table 15, Sink Products, suggests that liberation of the barite is improved with size reduction. However, from the standpoint of producing a mud-grade product, reduction to 2.5 cm prior to further treatment, for example wet jigging, probably would be satisfactory.

CONCLUSION

The results of this work indicated that a substantial recovery of mud-grade barite is feasible by pre-screening at 2.5 cm followed by reduction of the plus 2.5 cm fraction to, say, 1.5 cm and gravity treatment by a variety of methods, including wet jigging.

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Table 13. Sample size and description, plus 2.5 cm fractions

<u>Sample 1</u>	<u>Mesh Size</u> (mm)	<u>Description</u>
Coarse, +2.5cm reduced	-15, +5.0	80%+ barite, red to grey impurity, barite essentially liberated, minor carbonate*
	-5.0, +2.4	as above
	-2.4, +0.6	as above
	-0.6, +0.15	as above
	-0.15	off-white to light brown powder, vigorous reaction with HCl indicating carbonate.
*carbonate reaction on distinct and separate grains even in minus 15, +5 mm fraction; probably necessary to crush to only 15 mm prior to jigging although carbonate probably contains barite as well.		
<u>Sample 2</u>		
Coarse, +2.5cm reduced	-15, +5.0	50% barite, remainder brown to black mineral grains, minor carbonate
	-5.0, +2.4	as above
	-2.4, +0.6	as above, vigorous HCl reaction with individual grains
	-0.6, +0.15	as above
	-0.15	vigorous reaction with HCl
<u>Sample 3</u>		
Coarse, +2.5cm reduced	-15, +5.0	25% barite, grey to brown to red mineral impurity, impurities show reaction with HCl
	-5.0, +2.4	as above
	-2.4, +0.6	as above, white mineral as well as dark impurity show carbonate reaction
	-0.6, +0.15	fairly vigorous carbonate reaction
	-0.15	vigorous carbonate reaction
<u>Sample 4</u>		
Coarse, +2.5cm reduced	-15, +5.0	15 to 20% barite, remainder brown to grey to black mineral impurity with minor carbonate
	-5.0, +2.4	as above, carbonate reaction largely from white pieces
	-2.4, +0.6	as above
	-0.6, +0.15	as above
	-0.15	vigorous carbonate reactions
<u>Sample 5</u>		
Coarse, +2.5cm reduced	-15, +5.0	10 to 15% barite, remainder brown to grey, little evidence of calcite in 5 or 6 pieces tested
	-5.0, +2.4	as above
	-2.4, +0.6	as above, with several pieces of white calcite identified
	-0.6, +0.15	as above with more calcite in evidence
	-0.15	fairly reactive with HCl



Table 14. Sample size and description, minus 2.5 cm fractions

<u>Sample 1</u>	<u>Mesh Size</u> mm	<u>Description</u>
Fine, -2.5 cm	+2.4	80% barite, carbonate particles observed
reduced	-2.4, +0.6	as above
	-0.6, +0.15	as above, high carbonate
	-0.15	
<u>Sample 2</u>		
Fine, -2.5 cm	+2.4	10% or less barite, brown to grey impurity
reduced	-2.4, +0.6	as above
	-0.6, +0.15	as above, several pieces of white calcite
	-0.15	brown powder carbonate reaction not very pronounced
<u>Sample 3</u>		
Fine, -2.5 cm	+2.4	10% barite or less, no calcite reaction in fragments
reduced	-2.4, +0.6	checked
	-0.6, +0.15	as above but with several pieces of calcite
	-0.15	as above
		moderately high calcite
<u>Sample 4</u>		
Fine, -2.5 cm	+2.4	5% or less barite, minor calcite
reduced	-2.4, +0.6	as above, increase in calcite
	-0.6, +0.15	as above
	-0.15	as above
<u>Sample 5</u>		
Fine, -2.5 cm	+2.4	as per sample 4 above
reduced	-2.4, +0.6	as above
	-0.6, +0.15	as above
	-0.15	as above



Table 15. Test results, plus 2.5 cm fraction

Sample No.	wt. %	Mesh Fractions			Float 1,*		Float 2,**		Sink	
		Size mm	Net wt %	S.G.	wt %	S.G.	wt %	S.G.	wt %	S.G.
1	99	-2.5, +1.5	65.0	4.04	3.4	2.76	0.7	3.29	61.0	4.21
		-1.5, +5.0	18.9	4.17	0.8	2.76	0.4	3.08	17.7	4.30
		-5.0, +2.4	6.1	4.19	0.3	2.76	0.1	3.21	5.7	4.32
		-2.4, +0.6	5.5	4.23	0.3	2.73	0.1	3.14	5.1	4.40
		-0.6, +0.15	1.8	4.21	-	-	-	-	-	-
		-0.15,	1.7	4.19	-	-	-	-	-	-
			(99.0)	(4.09)	(4.8)		(1.3)		(89.5)	(4.25 ⁺)
2	99	-2.5, +1.5	63.4	3.78	6.5	2.70	6.0	3.24	50.8	4.15
		-1.5, +5.0	18.5	3.97	2.0	2.83	1.3	3.31	15.1	4.21
		-5.0, +2.4	6.6	3.98	0.7	2.78	0.4	3.25	5.5	4.31
		-2.4, +0.6	6.1	4.00	0.7	2.77	0.4	3.27	5	4.35
		-0.6, +0.15	2.2	3.99	-	-	-	-	-	-
		-0.15,	2.2	4.01	-	-	-	-	-	-
			(99.0)	(3.85)	(9.9)		(8.1)		(76.4)	(4.19 ⁺)
3	98	-2.5, +1.5	60.0	3.41	19.2	2.77	9.5	3.04	31.5	4.12
		-1.5, +5.0	21.3	3.59	6.9	2.83	2.1	3.28	12.3	4.30
		-5.0, +2.4	6.9	3.58	2.2	2.83	0.7	3.17	4.0	4.30
		-2.4, +0.6	5.8	3.59	1.8	2.82	0.5	3.17	3.5	4.34
		-0.6, +0.15	2.1	3.55	-	-	-	-	-	-
		-0.15,	1.9	3.70	-	-	-	-	-	-
			(98.0)	(3.47)	(30.1)		(12.8)		(51.3)	(4.19 ⁺)
4	92	-2.5, +1.5	28.3	3.38	9.3	2.70	3.0	3.22	16.3	4.05
		-1.5, +5.0	38.3	3.56	13.0	2.86	5.2	3.23	20.4	4.21
		-5.0, +2.4	10.7	3.48	3.9	2.85	1.0	3.28	5.7	4.24
		-2.4, +0.6	9.2	3.53	3.1	2.85	0.9	3.15	5.2	4.29
		-0.6, +0.15	3.1	3.56	-	-	-	-	-	-
		-0.15,	2.4	3.67	-	-	-	-	-	-
			(92.0)	(3.49)	(29.3)		(10.1)		(47.6)	(4.18 ⁺)
5	85	-2.5, +1.5	25.6	3.35	11.3	2.73	1.0	3.25	13.0	4.10
		-1.5, +5.0	35.4	3.49	13.3	2.83	2.2	3.28	19.5	4.26
		-5.0, +2.4	9.7	3.56	3.4	2.83	0.5	3.13	5.8	4.30
		-2.4, +0.6	8.4	3.58	2.9	2.82	0.5	3.13	5.0	4.35
		-0.6, +0.15	3.1	3.59	-	-	-	-	-	-
		-0.15,	2.8	3.62	-	-	-	-	-	-
			(85.0)	(3.47)	(30.9)		(4.2)		(43.3)	(4.23 ⁺)

* Float 1 obtained using heavy liquid of S.G. 2.97

**Float 2 obtained using sink from No. 1 and heavy liquid of S.G. 3.30



Table 16. Test results, minus 2.5 cm fractions

Sample No.	Net wt %	S.G. Range, Crushed Products	
1	1	4.18 (coarse) to 3.78 (fine)	
2	1	3.91	3.40
3	2	3.15	3.28
4	8	3.04	3.07
5	15	3.05	3.07